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Trace element distributions in cuttlefish (*Sepia officinalis*) statoliths in response to a manipulated environment

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Introduction

Cephalopod statoliths potentially act as information storage structures in which ambient changes of water salinity and temperature are recorded by their trace element composition. Therefore, statolith microchemistry provides a powerful tool to reconstruct life history events and migration pathways of individual cephalopods. Most microchemical studies focus on strontium concentrations to infer temperature related habitat use, yet the method remains largely unverified. It is not known if the strontium to calcium (Sr/Ca) ratio is primarily related to ambient temperature or if it is simultaneously influenced by salinity. We manipulated rearing environments of juvenile cuttlefish (*Sepia officinalis*) to quantify the relationship between statolith trace element composition and water salinity and temperature.

The common cuttlefish *Sepia officinalis*

Methods

Statoliths were ground to the widest plane in the lateral dome as doubly polished, 40 µm thick sections. Analytical points were distributed along the periphery of the lateral dome section (Fig. 3). Additionally, transects with evenly spaced points at 10µm intervals were analysed along the growth axis from the core region to the rim of the lateral dome (Fig. 7).

Electron microprobe analyses were carried out using a CAMECA SX 50 for the elements Ca, C, O and Sr. A nominal beam diameter of 5 µm was used.

Synchrotron X-ray fluorescence microprobe (SYXRF) analyses were performed at Beamline L in the Synchrotron Radiation Laboratories HASYLAB at DESY in Hamburg, Germany (Fig. 8). In the measurements we used white synchrotron radiation and a glass capillary producing a beam diameter of about 12 micrometers.

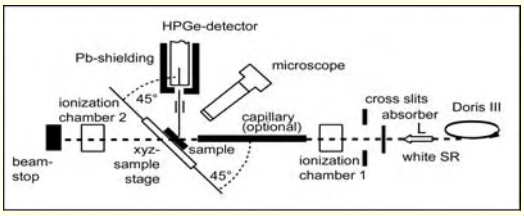

Fig. 8: Schematic SYXRF setup

Rearing experiments

Rearing experiments were performed to evaluate effects of salinity and temperature on statolith composition. Randomly selected *Sepia officinalis* hatchlings were adjusted to different salinities and temperatures and held for 60 days. *Ad libitum* feedings were conducted daily with mysid shrimp (Mysidacea).

Preliminary Results

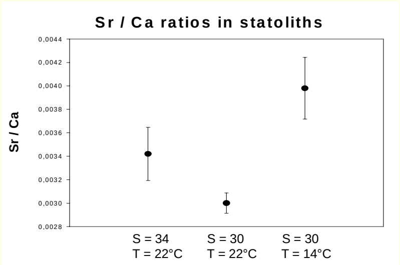

Fig. 1

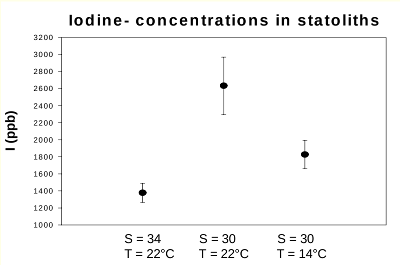

Fig. 2

Fig. 1: Sr/Ca ratio correlates positively with salinity and negatively with temperature. n= 14 spots. error bars represent standard deviation.

Fig. 2: Iodine concentration correlates negatively with salinity and positively with temperature. n= 14 spots. error bars represent standard deviation.

Fig. 3: Ground statolith showing the location of analytical points as red dots. We concentrated our analyses on the outer part of the lateral dome, a region that has definitely been formed during the rearing period.

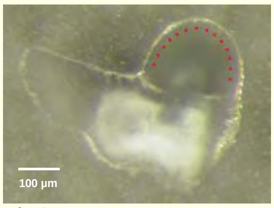

Fig. 3

Concentration profiles from core to rim

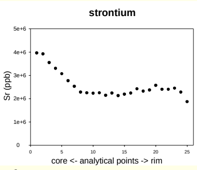

Fig. 4

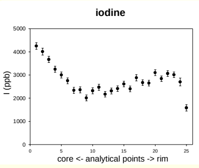

Fig. 5

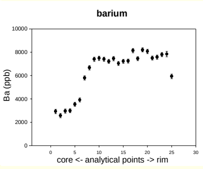

Fig. 6

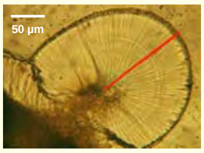

Fig. 7

Figs. 4, 5 and **6:** Distribution of strontium, iodine and barium concentrations along the growth axis of the lateral dome. Error bars represent 95% confidence interval.

Fig. 7: Ground statolith showing the location of analytical points. The transect of analyses is shown as a red line.

A chemical zonation is visible in all statoliths: In the core region we found an extremely high Sr and iodine concentration and a very low barium concentration. The observed strong decrease in strontium and Iodine and the increase of barium probably reflects the time of hatching.

Conclusions

Previous studies indicate that uptake of strontium into cephalopod statoliths is negatively correlated with temperature. Our experimental results, however, show a strong covariation between strontium contents and both temperature and salinity. Preliminary, qualitative results further show that iodine correlates positively with temperature and negatively with salinity. Ongoing rearing experiments will be used to quantitatively calibrate the influence of temperature and salinity on the trace element composition of statoliths. Such calibration curves will provide opportunities to interpret data from the field in term of both temperature and salinity.

The high micro-scale resolution and the precise analysis of heavy trace elements makes **SYXRF** an excellent tool to gather life history information of individual cuttlefish from their statoliths. The **electron microprobe** proved to be a useful tool for analysing abundant elements like strontium in statoliths.

Acknowledgements

Armin Form collected eggs of *Sepia officinalis* and assisted in the rearing experiments. Mario Thöner and Frank Lechtenberg provided expertise and assistance with the microprobe analyses.

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